What is claimed is:

Sub A1

1. An apparatus for treating exhaust from an internal combustion engine in communication with an exhaust pipe, comprising:

an oxidizing catalyst bed disposed in the exhaust pipe;

a reducing catalyst bed disposed in the exhaust pipe downstream from the oxidizing catalyst bed;

a source of hydrogen having a first control valve providing fluid communication with the oxidizing catalyst bed, a second control valve providing fluid communication with the reducing catalyst bed, and a third control valve providing fluid communication with the internal combustion engine;

a source of oxygen having a control valve providing fluid communication with the oxidizing catalyst bed;

a control system for conditioning the oxidizing catalyst bed prior to receiving significant amounts of exhaust having a component selected from HCs, CO or combinations thereof, conditioning the reducing catalyst bed prior to receiving significant amounts of exhaust having NOx, and providing hydrogen to the internal combustion engine during cold start.

2. The system of claim 1, wherein the oxidizing catalyst bed is conditioned during a cold start ignition by opening the first hydrogen control valve and the oxygen control valve.

3. The system of claim 1, wherein the reducing catalyst bed is conditioned by opening the second hydrogen control valve.

4. The system of claim 2, wherein the oxidizing catalyst bed is conditioned until reaching a light off temperature.

5. The system of claim 1, wherein the reducing catalyst is conditioned continuously or discontinuously throughout operation of the internal combustion engine.

6. The system of claim 1, wherein the oxidizing catalyst bed is selected from a two-way catalyst, a three-way catalyst or combinations thereof.

7. The system of claim 1, further comprising hydrogen delivery ports in communication with one or more regions of the reducing catalyst bed.

8. The system of claim 1, wherein the reducing catalyst monolith includes essentially no catalyst capable of oxidizing nitrogen.

9. The system of claim 1, wherein the hydrogen source includes an on-board electrolyzer.

10. The system of claim 9, wherein the on-board electrolyzer has an anode for producing oxygen, and wherein the anode is in fluid communication with the oxygen source.

11. The system of claim 1, wherein hydrogen is provided to the internal combustion engine during cold start by opening the third hydrogen control valve.

12. A method for preventing and treating emissions in exhaust gas from an internal combustion engine, comprising:

supplying hydrogen fuel to a internal combustion engine during cold start;

passing the exhaust gas over one or more oxidizing catalysts and then over one or more reducing catalysts;

oxidizing one or more oxidizable components in the exhaust gas over the oxidizing catalysts;

providing hydrogen gas into the reducing catalysts; and

reducing one or more reducible components in the exhaust gas over the reducing

21. The method of claim 20, further comprising:

heating the oxidizing catalysts by exothermic catalytic combination of hydrogen and oxygen up to a light-off temperature.

22. The method of claim 20, wherein after the engine warm-up period the hydrogen is substantially continuously provided to the reducing catalysts.

23. The method of claim 12, further comprising electrolytically producing the hydrogen at a rate proportional to the load on the internal combustion engine.

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~~24~~. The method of claim 23, further comprising:

starting the electrolyzer and providing hydrogen to the reducing catalysts only after an engine warm-up period.

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25. The method of claim 24, wherein after the engine warm-up period the hydrogen is substantially continuously provided to the reducing catalysts.

26. The method of claim 24, wherein after the engine warm-up period the hydrogen is discontinuously provided to the reducing catalysts.

27. The method of claim 12, further comprising:

heating the oxidizing catalysts by exothermic catalytic combination of hydrogen and oxygen up to a light-off temperature.

28. The method of claim 12, further comprising:

providing hydrogen to the reducing catalysts before the exhaust gas stream contacts the reducing catalysts.

24.

~~29~~. The method of claim 23, further comprising:

storing a portion of the produced hydrogen in a hydrogen storage vessel.

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catalysts.

13. The method of claim 12, wherein the one or more reducing catalysts is selected from Pt, Ru, Pt-alloys, Ru-alloys and combinations thereof.

14. The method of claim 12, further comprising:

providing hydrogen to the reducing catalysts; and

reducing nitrogen oxides to nitrogen gas and water vapor at the reducing catalysts.

15. The method of claim 12, wherein the one or more oxidizable components are selected from hydrocarbons, carbon monoxide or combinations thereof and the one or more reducible components include nitrogen oxides.

16. The method of claim 12, wherein the internal combustion engine burns a fuel selected from gasoline, diesel, natural gas or methanol after cold startup.

17. The method of claim 12, wherein the hydrogen is provided to the reducing catalysts only after an engine warm-up period.

18. The method of claim 17, wherein hydrogen is substantially continuously provided to the reducing catalysts after the engine warm-up period.

19. The method of claim 17, wherein the hydrogen is provided to the reducing catalysts before an engine warm-up period to condition the reducing catalysts prior to introducing nitrogen oxides.

20. The method of claim 16, further comprising:

providing hydrogen and oxygen to the oxidizing catalysts at a time selected from before the internal combustion engine is started or before the exhaust gas stream contacts the oxidizing catalysts.

30. The method of claim 29, wherein the hydrogen provided to the oxidizing catalysts is supplied from the hydrogen storage vessel.

31. The method of claim 30, further comprising:

stopping hydrogen to the oxidizing catalysts after the oxidizing catalysts reach a light-off temperature.

32. The method of claim 31, further comprising providing hydrogen into the engine.

33. The method of claim 32, wherein the hydrogen is provided into the engine for about one minute or more following startup.

34. The method of claim 32, wherein the hydrogen is provided into the engine for between about 30 seconds and about one minute.

35. The method of claim 32, wherein the hydrogen is provided into the engine for between about 10 and about 15 seconds.

36. The method of claim 12, wherein the reducing catalysts are dispose on a support material selected from alumina, silica, zeolite, and titanium dioxide.